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(54) Title: GAS FILTRATION/PURIFICATION DEVICE

(57) Abstract: The present invention relates to a filter alone or in combination one, two or more of porous filters, diffusers, purifiers or getters. It is designed to be mounted to a container of pressurized gas, either in gaseous or liquid form used in the semiconductor industry in order to reduce the amount of contamination or impurities introduced into the semiconductor tool. The filters may be made of plastics such as PTFE resin or ultrahigh molecular weight polyethylene or porous sintered metals such as stainless steel, nickel, chromium or titanium, alloys of these metals or blends of the metals. The filter is preferably designed to act as a filter and gas diffuser although a separate diffuser may also be used. The purifier and the getter are designed to remove specific impurities, such as water, before they enter the system.

Gas Filtration / Purification Device

This invention relates to a filtration and/or purification device for high purity gas used in the semiconductor industry. More particularly, it relates to a gas filtration device that is attached to the point of initial distribution of the gas.

Background of the Invention

The use of specialty gases in the semiconductor industry is widespread. Such gases are used to form various layers upon the semiconductor wafer as well as to treat or etch the wafer surface in preparation for the formation of an additional layer. These gases must be of the highest purity available as any impurities or particulate matter contained within the gas stream will cause an imperfection on the surface of the wafer. Such imperfections result in the loss of product during production results in lower yields, higher scrap rates and higher production costs.

To avoid or at least reduce the chance of such impurities or particulate matter from reaching the wafer surface, one has traditionally used a series of filters and/or purifiers at the point of introduction of the gas into the semiconductor process chamber. This has often been referred to as the point of use application.

Gases are provided to the system in one of two conventional methods. The first is to generate the gas on site and deliver it to the system through a series of pipes. The second is to generate the gas offsite and deliver it in a pressurized gas cylinder either as a liquid or a gas, that is then connected to a piping system which delivers the gas, at, above or below the ambient pressure as required to the processing equipment.

In either system, impurities and particulate matter can be introduced into the system at the point of initial delivery of the gas to the system. These impurities and particulate matter can reside within the system for some time and cause various problems within the system. For example, the presence of

water as an impurity can cause corrosion of various components within the system. Additionally, if the water is not removed at the point of use, it will interact with various components of the wafer forming process and cause defects upon the wafer surface. Likewise, the introduction of particulate matter into the system adds an additional filtration burden to the point of use filters. Such matter may actually reside within the system for some period of time and may only move towards the point of use filter upon some unusual circumstance such as a pulse in the gas pressure. This would cause an abnormally high concentration of particles within the gas supply.

What is desired is a means for removing impurities and/or particulate matter upon the gas stream before it is introduced into the system. This would provide an additional level of purity and extend the life of the point of use filters and purifiers. The present invention provides such a means.

Summary of the Invention

A filter or filter/purifier device for use on a cylinder of gas to be supplied is disclosed by the present invention. The device has a housing that is capable of being attached in line to the cylinder. The housing contains one or more filters. The device is located either adjacent to and downstream of the cylinder outlet or is downstream of and in direct fluid communication with the cylinder outlet. It is mounted externally of the cylinder. The preferred device is both a filter and purifier so that it removes the particulate as well as a selected impurity or impurities from the gas as it exits the cylinder and enters the system. Impurities to be removed include water, carbon dioxide, carbon monoxide, oxygen and various metal carbonyls and other such impurities commonly found in gas streams.

It is a first object of the present invention to provide a filtration device for bottled gases comprising a filter housing, the housing having a first end and a second end, the first end having an inlet selected to form a gas tight seal with an outlet of the container, the second end having an outlet from the housing selected to form a gas tight seal with equipment using the gas, and

the housing containing one or more filter elements arranged such that all gas flowing from the inlet to the outlet of the housing flows through the one or more filter elements.

It is a second object of the present invention to provide a filtration device for bottled gases comprising a filter housing, the housing having a first end and a second end, the first end having an inlet selected to form a gas tight seal with an outlet of a gas bottle or the gas bottle valve, the second end having an outlet from the housing selected to form a gas tight seal with equipment using the gas, and the housing containing one or more filter elements arranged so as to form a gas tight seal between the inlet and outlet of the housing such that all gas flowing from the inlet to the outlet of the housing must flow through the one or more filter elements.

It is a third object of the present invention to provide a filtration device for bottled gases comprising a filter housing, the housing having a first end and a second end, the first end having an inlet selected to form a gas tight seal with an outlet of a gas bottle or a valve of the bottle, the second end having an outlet from the housing selected to form a gas tight seal with equipment using the gas, the housing containing one or more filter elements arranged such that all gas flowing from the inlet to the outlet of the housing flows through the one or more filter elements and the housing containing one or more purifying materials, the purifying materials being permanently retained within the housing and located in the housing between the downstream side of the one or more filter elements and the housing outlet. The purification material, when it is granular and free flowing, is contained between two filters.

It is a fourth object of the present invention to provide a filtration device for bottled gases comprising a filter housing, the housing having a first end and a second end, the first end having an inlet selected to form a gas tight seal with an outlet of a gas bottle, the second end having an outlet from the housing selected to form a gas tight seal with equipment using the gas, the housing containing one or more filter elements arranged such that all gas flowing from the inlet to the outlet of the housing flows through the one or more filter elements and wherein each of one or more filter elements is

formed of three or more layers integrally bonded to the other, wherein the outer layers are formed of sintered particulate metal filtration media and at least one of the inner layers is formed of a getter material.

It is an object of the present invention to provide a gas delivery system comprising a tank for gas, an outlet from the tank, a filtration device, the filtration device having a housing, the housing having a first end and a second end, the first end having an inlet selected to form a gas tight seal with an outlet of the container, the second end having an outlet from the housing selected to form a gas tight seal with equipment using the gas, and the housing containing one or more filter elements arranged such that all gas flowing from the inlet to the outlet of the housing flows through the one or more filter elements.

It is an object of the present invention to provide a gas delivery system comprising a cylinder for holding gas in liquid or gaseous form, an outlet, a filtration device, the device having a housing, the housing having a first end and a second end, the first end having an inlet selected to form a gas tight seal with an outlet of the container, the second end having an outlet from the housing selected to form a gas tight seal with equipment using the gas, and the housing containing one or more filter elements and the housing containing one or more purifying materials, the purifying materials being permanently retained within the housing, the one or more filters and purifying materials arranged such that all gas flowing from the inlet to the outlet of the housing flows through the one or more filter elements and purifying materials.

These and other objects and embodiments of the present invention will be clear to one of ordinary skill in the art from the following detailed description of the invention and the appended claims.

In The Drawings

Figure 1 shows a first embodiment of the present invention.

Figure 2 shows a second embodiment of the present invention.

Figure 3 shows a third embodiment of the present invention.

Figure 4 shows a fourth embodiment of the present invention being located downstream of the cylinder valve.

Detailed Description of the Invention

Figure 1 shows a first preferred embodiment of the present invention. A gas cylinder or container 1, which contains either a pressurized gas or a liquefied gas, is shown. It has a cylinder outlet 2 to which a filter device 3 has been mounted. As shown, this device 3 is mounted downstream or outside of the cylinder outlet 2. It is in direct communication with the cylinder outlet 2. The device 3 is formed of a housing 4 that has an inlet 5 and an outlet 6 with one or more filter elements 7 situated between the inlet 5 and the outlet 6 such that all fluid which passes from the cylinder outlet 2 must pass through the one or more filter elements 7 before reaching the device outlet 6. The device outlet 6 is attached to the supply system for the equipment (not shown) which will use the gas.

In Figure 2 is shown a further embodiment of the present invention. In this embodiment, in addition to the filte r 21, there are one or more purifier materials 22 contained within the housing 23 as well. The purifier 22 as shown in this embodiment is in a granular form although it may be in a solid form so long as adequate gas flow at acceptable pressure drops through purifier can be achieved. The purifier in this embodiment due to its granular nature needs a retaining device 24 such as glass frit, a screen or a second filter to hold it in place and prevent its loss either during shipping or use. It is preferred that when using a granular purifier that the downstream retaining device be a second filter. In some cases, the first filter upstream of the purifier is the primary means for removing particulates and the second filter need not have the same porosity or particle retention characteristics as the first. In this embodiment, it is preferred that the second filter is less retentive to lessen pressure drops across the device and it be sufficient to prevent the granular purifier material from escaping. Alternatively, especially when the purifier media is relatively "dirty" or tends to sheds particles, it is preferred that the

second filter downstream of the purifier media be either of the same or greater retentive ability as the upstream, first filter.

In Figure 3 is shown a third embodiment of the present invention. In this embodiment, the housing 31 contains two layers of filter 32,33 with a layer of getter material 34 sandwiched in between. Such a material is taught by US Patent 5,456,740 that is incorporated herein by reference in its entirety. Getter materials are preferably formed of metals, metal hydrides, metal alloys or mixtures of one or more of these components that is in itself reactive towards gas impurities. Getter material is made from getter alloy or pure metal that is unreactive at ambient temperature due to a protective oxide coating but behaves as a getter either at elevated temperatures or at ambient temperatures after having been subjected to an elevated temperature activation treatment. Typical metals include but are not limited to aluminum, calcium, hafnium, magnesium, manganese, strontium, titanium, vanadium and zirconium. Preferred metals are zirconium, titanium, their alloys and blends of such metals. Suitable alloys include binary alloys such as zirconium/aluminum in an 84/16% ratio (SAES ST 101getter) and tertiary alloys such as zirconium/titanium/nickel. Such materials can be formed in-house or obtained from getter manufacturers such as SAES Getters S.p.A of Milan, Italy.

While the three layer getter of Figure 3 is preferred, other arrangements may be made, such as using a getter material which also acts as a particulate filter or arranging a getter and one layer of filter in the device.

Figure 4 shows another embodiment of the present invention where the cylinder outlet 40 of the cylinder 41 is first attached to a cylinder valve 43 having its inlet 44 sealably attached to the cylinder outlet 40 and the device 45 of the present invention being downstream of the cylinder valve 43. As shown, the device 45 is secured to the outlet 46 of the cylinder valve 43 at its inlet 47. The outlet 48 of the device connects to either the gas processing equipment or a supply line for that equipment (not shown). The device in this Figure uses a membrane 49 as in Figure 1. Alternatively, it may be located downstream from that location, but be in a position upstream of the gas

processing system. Any of the filter/ purifier/getter designs of Figures 1-3 may be used in this embodiment.

The filtration material of the present invention may be selected from the group of porous filtration materials such as porous sintered metal, including stainless steel, nickel, chromium, titanium, Hastalloy or Inconel, porous ceramics, or porous polymers such as PTFE resin sheets PFA and other perfluorinated thermoplastic resins and polyolefins.

All of these filtration materials are available from a variety of sources. Preferred materials include stainless steel filter elements known as SF filter elements and nickel filter elements known as NF elements available from Millipore Corporation of Bedford, Massachusetts. A preferred plastic porous material is a PTFE porous filtration sheet known as WAFERGARD ® filters available from Millipore Corporation of Bedford Massachusetts.

Preferably, the material is a porous sintered metal. By porous sintered metal, it is meant a material formed of a plurality of metal particles which have been loosely packed together and then sintered together into a form-stable shape. As these particles only sinter where they touch each other, spaces or pores are formed between the particles.

Preferred metals for such a material include stainless steel, nickel and chromium although other metals may be used so long as they are inert to the gases which flow through the gas line and the metals are capable of being formed into porous sintered metal products.

The shape of the particle is not critical to the present application provided it allows for the proper laminar flow and particle retention. Typically these particles are in the form of dendritic particles, spherical particles, irregular particles or fibrous particles. The formation of such particles and their use in porous sintered metal filtration devices is well known, see US Patents US 5,487,771, US 5,814,272 and US 5,114,447,the teachings of which are incorporated herein in their entireties.

The porous sintered metal filtration material may be in the form of a flat sheet or tube. When in the form of a flat sheet, it is preferred that the material be in a circular or ellipsoid shape so as to create a uniform laminar flow

through the diffuser. However, the use of other shaped sheets, such as square, rectangular or triangular sheets may occur so long as the laminar flow and flow/unit area are maintained. The flat sheet may be used directly as a filter element or it may be formed into a series of stacked disks which form the filter of the device, see US Patents 5,114,447 and US 5,487,771, the teachings of which are incorporated in their entireties.

When in the form of a tube, one end of the tube must be closed in order to achieve filtration. The end may be porous or non-porous, with a porous end being preferred in order to achieve laminar gas flow. The porous end cap may be formed as part of the sintering process which is preferred or it may be a porous or non-porous cap that is welded or otherwise secured to the end of the tube.

The porous sintered metal materials preferably have porosity ranging from about 35% to about 80%, preferably at least 40% and more preferably between 40% and 80%. Regardless of the porosity, the filtration material must be able to remove most particles typically found in gas streams and prevent them from passing through the diffuser and into the chamber while providing the gas flow at a low pressure drop. Typically, filtration materials that are capable of removing particles of a diameter of 0.003 microns or greater are preferred see US Patents 5,114,447 and US 5,487,771, the teachings of which are incorporated in their entireties for methods of sintering such filter elements.

The housing typically is formed of the same material as the filtration material, namely metal, ceramic or plastic. However, the housing may be formed of a material different from that of the filtration material so long as it is capable of forming a seal between its inner circumference and the filtration material and does not cause any adverse interactions between the two materials. Unlike the filtration material, the housing should not be porous especially when used on the exterior of the cylinder.

The filtration material may be sealed to the inner circumference of the housing in a variety of ways, depending upon the select of the filtration material and the housing.

For example, when using metal for both the filtration material and the housing, the filtration material may be welded, soldered or chemically bonded to the metal surface of the housing. Alternatively, the metal housing may be formed of two pieces such that the filtration material is placed between the two pieces and the two pieces are then attached to each other via a weld, soldered line or chemical bonding. Additionally, when using a plastic filtration material with the metal housing, one may heat bond or adhere the two together.

When using a plastic housing, it may be injection molded to be outer periphery of the filtration material, or the filtration material may be adhered to the housing. Alternatively, when both are plastic, the filtration material may be heat sealed, ultrasonically welded or friction bonded to the housing. Additionally, when one seals a metal filtration material to a plastic housing, one may heat the metal to a temperature above the melting point of the housing and simply melt bond the filtration material into the housing to form a seal.

Ceramic filtration materials may preferably be used with a plastics housing and may be attached via injection molding, adhesive or in some cases melt bonding. The ceramic material may actually be formed as one piece containing both the housing and the porous filtration material. In this instance, it is preferred to then render the housing portion of the ceramic device non-porous, such as by treating that portion with a glaze or filler.

Typically purifiers are designed to remove one or more selected impurities from a gas. Most purifier materials are impurity and gas specific e.g. a CO purifier removes metal carbonyls from CO but these impurities are not found in other gases. In the event that one wishes to remove more than one impurity, a blend of purifier materials may be used. Such purifier materials are well known and are typically based on metals or resins which have specific chemically reactive capabilities for various impurities. They are designed to scavenge and bind the impurities so as to remove them from the gas stream. See U.S.Patents 4,603,148; 4,604,270; 4,853,148; 4,925,646; 4,948,571;

5,135,548; 5,340,552; EP 0366 078 A3; WO 90 / 07971 for examples of these purifiers and how to make them.

The typical impurities which are removed include but are not limited to H_2O, O_2, CO_2, CO, CH_4, hydrocarbons, etc. from gases but not all remove all these from all gases. Suitable types include those available from Millipore of Bedfo rd, Massachusetts under the name of Reactive Micro Matrix (RMM) purifiers, which are resin based purifiers, from Aeronex Inc. of San Diego California under the name GateKeeper purifiers, which are nickel based metallic pellets or from Semi-Gas Systems, a division of Matheson Gas Products of San Jose, California under the name Nanochem purifiers, which are resin-based purifiers.

Either CGA (Compressed Gas Association) or DISS (Diameter Index Safety System) fitting may be used to attach the housing to the cylinder, Additionally, one may use a restrictive flow orifice or flash arrestors attached directly to the cylinders for safety reasons and attach the housing to that device and still achieve the same results.

One method for defining the efficiency of a filter is the flow/unit area of filtration media (defined as the surface area of the filter, e.g. one surface when in the form of a sheet or flat disk and the average of the two outer surfaces when in the form of a tube) for a stated LRV. For example, one filter of the present invention, a nickel disk, has a surface area of $16.4cm^2$ and achieves a LRV of 9 at a flow of 70 SLPM resulting in a flow/unit area filter of 4.5 SLPM/cm^2. Preferably, the flow /unit area is measured at 9 LRV and for a device of the present invention is at least 0.75 SLPM/cm^2 at 9LRV. A range of suitable values is from about 0.75 to about 6 SLPM/cm^2 at 9LRV,preferably from about 1 to about 4.5 SLPM/cm^2 at 9LRV and more preferably from about 2 to about 4.5 SLPM/cm^2 at 9LRV.

An alternative and less accurate method of defining filter efficiency is to give the LRV or log reduction value for a filter at a given flow rate and at its most penetrating particle size, see the article by Rubow, et.al.," Characteristics of Ultra-High Efficiency Membrane Filters in Gas Applications", Journal of Environmental Sciences, Vol. 31,pgs 26-30 (May 1988). A filter

capable of retaining of 99.9% particles at its most penetrating particle size is a LRV of 3. This value is typically determined by comparing the ratio of the number of particles impacting the upstream side of the filtration material with the number of particles that actually pass through the material and are detected on the downstream side of the material. Therefore, a LRV of 3 would imply that a challenge of 10x3 particles of the most penetrating size were directed against the filtration material and only one particle was detected downstream of the filter. The log of that value is 3, thus resulting in the LRV of 3.

Typically this test is conducted by generating an aerosol of several million particles with a size distribution centered around the most penetrating particle size, passing this aerosol through the filter and counting the number of particles that pass with a condensation nucleus counter (CNC). Preferably, the filtration material will have a LRV of at least 3 and more preferably at least 6 and most preferably 9, for its most penetrating particle size at a flow of from about 1 to 200 SLPM, preferably at a flow of between about 1 and about 90 SLPM.

What is Claimed:

1. A filtration device for bottled gases comprising a filter housing, the housing having a first end and a second end, the first end having an inlet selected to form a gas tight seal with an outlet of a gas bottle, the second end having an outlet from the housing selected to form a gas tight seal with equipment using the gas, and the housing containing one or more filter elements arranged such that all gas flowing from the inlet to the outlet of the housing flows through the one or more filter elements.

2. The device of claim 1 wherein the one or more filter elements are arranged so as to form a gas tight seal between the inlet and outlet of the housing such that all gas flowing from the inlet to the outlet of the housing must flow through the one or more filter elements.

3. A filtration device for bottled gases comprising a filter housing, the housing having a first end and a second end, the first end having an inlet selected to form a gas tight seal with an outlet of a gas bottle, the second end having an outlet from the housing selected to form a gas tight seal with equipment using the gas, the housing containing one or more filter elements arranged such that all gas flowing from the inlet to the outlet of the housing flows through the one or more filter elements and the housing containing one or more purifying materials, the purifying materials being permanently retained within the housing and located in the housing between the downstream side of the one or more filter elements and the housing outlet such that all gas flowing from the inlet to the outlet of the housing flows through the one or more filter elements and the housing.

4. The device of claims 1 and 3 further comprising a cylinder valve between the cylinder outlet and the housing inlet.

5. The device of claims 1 and 3 wherein the one or more filter elements are made of materials selected from the group consisting of PTFE resin, PFA and other perfluorinated thermoplastic resins, polyolefins, ultrahigh molecular weight polyethylene, ceramics and metals and wherein the one or more elements act as a gas diffuser in addition to filter elements.

6. The device of claims 1 and 3 wherein the one or more filter elements are made of materials selected from the group consisting of PTFE resin, PFA and other perfluorinated thermoplastic resins, polyolefins, ultrahigh molecular weight polyethylene, ceramics and metals and wherein the one or filter elements have a log reduction value (LRV) of greater than 3 measured at its most penetrating particle size.

7. The device of claims 1 and 3 wherein the one or more filter elements are made of materials selected from the group consisting of PTFE resin, PFA and other perfluorinated thermoplastic resins, polyolefins, ultrahigh molecular weight polyethylene, ceramics and metals and wherein the one or filter elements have a log reduction value (LRV) of at least 9 measured at its most penetrating particle size.

8. The device of claims 1 and 3 wherein the one or more filter elements are made of materials selected from the group consisting of PTFE resin, PFA and other perfluorinated thermoplastic resins, polyolefins, ultrahigh molecular weight polyethylene, ceramics and metals and wherein the one or filter elements have a flow/unit area of from about 0.75 to about 6 SLPM/cm^2 at 9LRV.

9. The device of claims 1 and 3 wherein the one or more filter elements are made of one or metals selected from the group consisting of stainless steel, nickel, chromium, titanium, alloys thereof and blends thereof.

10. The device of claims 1 and 3 wherein the one or more filter elements are made of nickel and alloys thereof.

11. The device of claims 1 and 3 wherein the one or more filter elements are made of stainless steel.

12. The device of claims 1 and 3 wherein the one or more filter elements are made of chromium and alloys and blends thereof.

13. The device of claim 3 wherein the purifying material is selected to remove one or more impurities selected from the group consisting of H_2O, O_2, CO_2, CO, CH_4, hydrocarbons, metal carbonyls and combinations thereof.

14. The device of claim 3 wherein the purifying material is particulate in form and is packed between the downstream side of the last of the one or more filter elements and a porous material downstream of the purifying material.

15. The device of claim 3 wherein the purifying material is particulate in form and packed between the downstream side of the last of the one or more filter elements and a porous material downstream of the purifying material and wherein the porous material is selected from the group consisting of frit, filter elements and diffusers.

16. The device of claim 3 wherein the purifying material is particulate in form and is packed between the downstream side of the last of the one or more filter elements and a porous material downstream of the purifying material, wherein the porous material is selected from the group consisting of frit, filter elements and diffusers, wherein the frit, filter elements and diffusers used to retain the purifying material within the housing is formed of a material selected from the group consisting of glass, ceramics and metals.

17. A filtration device for bottled gases comprising a filter housing, the housing having a first end and a second end, the first end having an inlet, the second end having an outlet from the housing, the housing containing one or more filter elements arranged such that all gas flowing from the inlet to the outlet of the housing flows through the one or more filter elements and wherein each of one or more filter elements is formed of three or more layers integrally bonded to the other, wherein the outer layers are formed of sintered particulate metal filtration media and at least one of the inner layers is formed of a getter material.

18. The device of claim 17 wherein the sintered particulate metal filtration media is selected from the group consisting of stainless steel, nickel, chromium and alloys thereof and the getter material is selected from the group consisting of aluminum, calcium, hafnium, magnesium, manganese, strontium, titanium, vanadium and zirconium, their alloys and blends of such metals and alloys.

19. A gas delivery system comprising a container for pressurized or liquidified gas, the container having an outlet, a filtration device, the device having a housing, the housing having a first end and a second end, the first end having an inlet selected to form a gas tight seal with the outlet of the container, the second end having an outlet from the housing selected to form a gas tight seal with equipment using the gas, and the housing containing one or more filter elements arranged such that all gas flowing from the inlet to the outlet of the housing flows through the one or more filter elements.

20. The system of claim 19 further comprising the housing contains one or more purifying materials for removing impurities from the gas.

21. The system of 19 further comprising a valve attached to the container and being upstream of the filtration device.

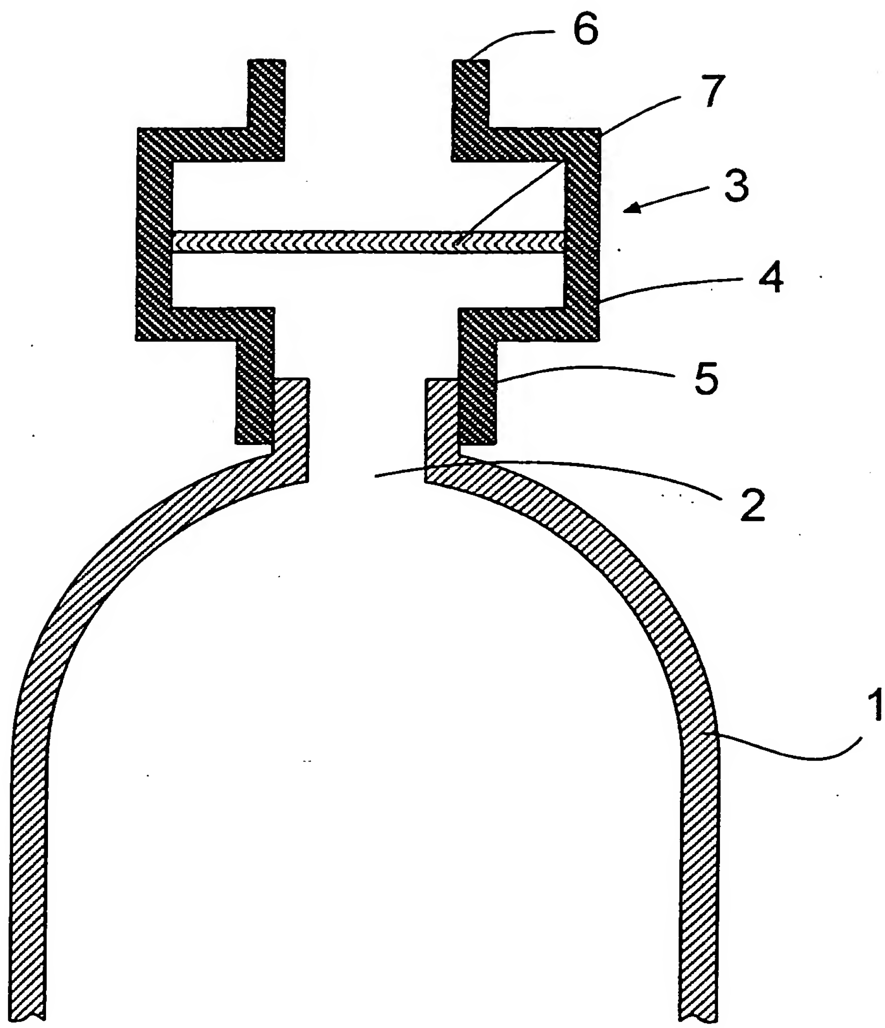

Fig. 1

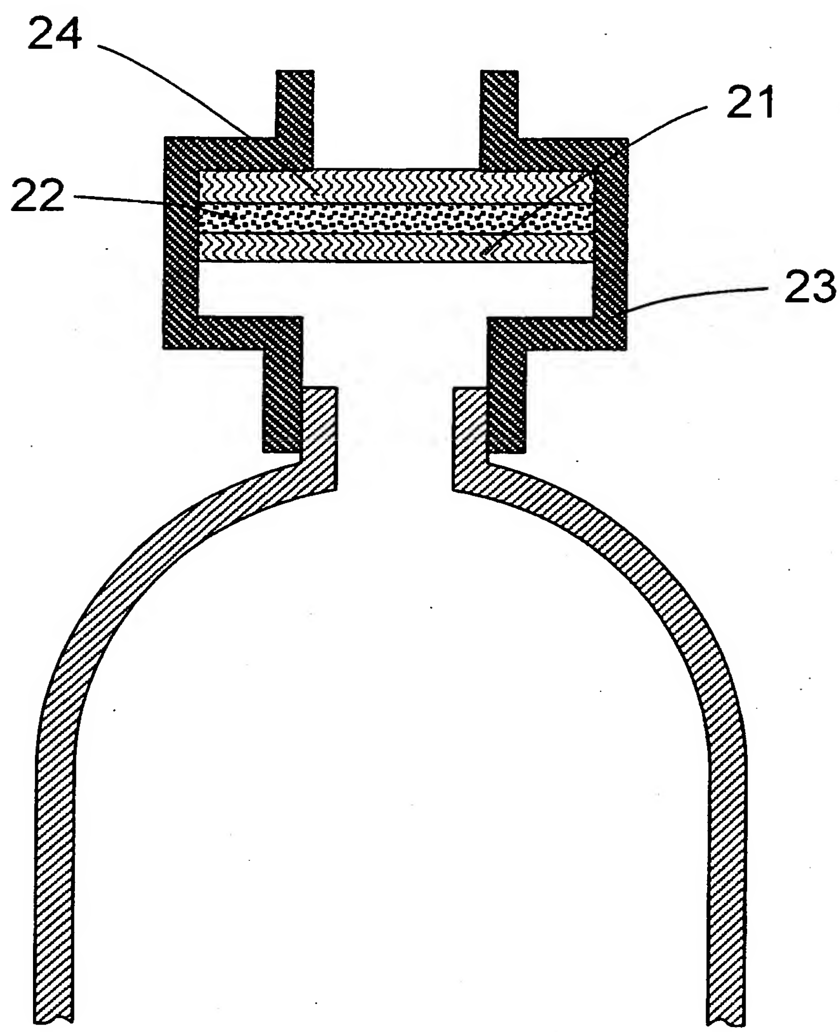

Fig. 2

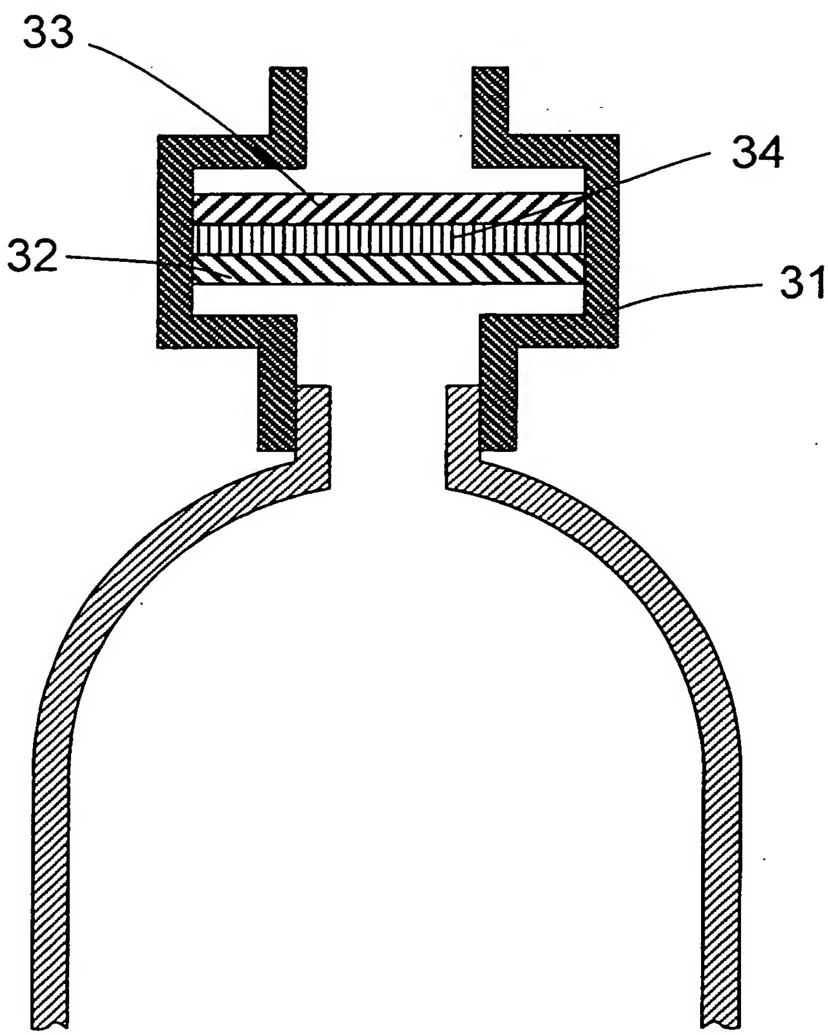

Fig. 3

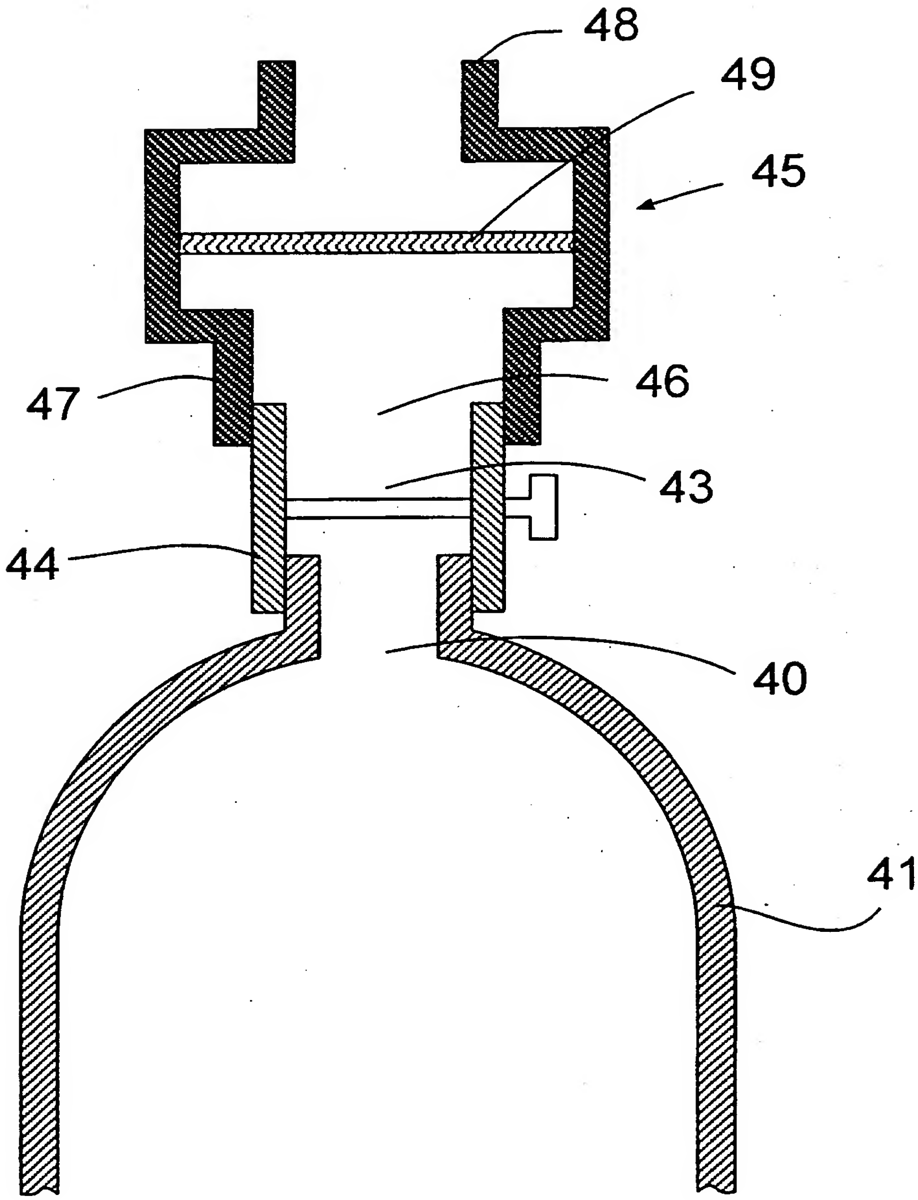

Fig. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/27326

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D46/00 F17C13/00 B01D53/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D F17C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, PAJ, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 591 840 A (AIR PROD & CHEM) 13 April 1994 (1994-04-13) claim 1	1-4,13, 19,21
A	US 4 032 311 A (BOHMRICH JACK L ET AL) 28 June 1977 (1977-06-28) claim 1; figure 1	1-4,19, 21
A	DE 23 23 013 A (DRAEGERWERK AG) 28 November 1974 (1974-11-28) claim 1	1-3,9, 13,19
A	US 4 836 242 A (COFFRE ERIC ET AL) 6 June 1989 (1989-06-06) claim 1	1,3,19

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
26 January 2001	06/02/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Faria, C

1

Inter nal Application No
PCT/US 00/27326

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 504 092 A (MOTT METALLURG CORP) 16 September 1992 (1992-09-16) cited in the application abstract	9
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